WISCONSIN ENDANGERED RESOURCES REPORT # 115

Distribution, Current Population Status, Growth and Habitat of Goblin Fern (Botrychium mormo) in Wisconsin

By: William E. Tans and Dreux J. Watermolen

SUMMARY

The Goblin Fern (*Botrychium mormo* Wagner), a Wisconsin endangered plant, appears sporadically in second growth forests in the northern part of the state. Although previously documented from only a few comparable habitats in Minnesota, northern Wisconsin and Michigan's Upper Peninsula, regional botanists conducting intensive, focused searches have discovered nearly 50 new populations in Wisconsin in the last few years, resulting in a total of 55 element occurrences. We have combined our field observations with information from the three states' Natural Heritage Inventory programs to develop an updated distribution map for the entire range of this regional endemic.

Goblin ferns occur in varying aged deciduous, northern mesic hardwoods dominated by sugar maple and basswood. The entire plant is contained in the several-centimeter deep humus layer comprised primarily of sugar maple leaves in various stages of decomposition. A list of associated plants is included, and other *Botrychium* species found in similar Wisconsin habitats are listed.

Preliminary observations from monitoring four populations over three years indicate that the diminutive Goblin Fern appears above the leaf litter in late June and reaches maximum population levels in mid-July through August. Individual plants may appear at any time during late summer or even after leaf fall, and begin senescence in mid-September. In any given population, there may be many individual plants that never emerge above the leaf litter, making it difficult to accurately census populations of this species. Prior to senescence, some plants are buried by autumn leaves.

Preliminary observations suggest Goblin Fern is a short-lived perennial plant. It has been reported that the sporangia do not open, but at least some sporangia dehisce in late summer or early fall. However, spores apparently disperse only very short distances. Preliminary results from field experiments suggest that Goblin Ferns can be transplanted successfully.

Soil moisture appears to be the most significant environmental factor affecting plant growth and population structure. Small plants rapidly dwindle and disappear during dry conditions. Implications for the management and conservation of Goblin Ferns in Wisconsin are briefly discussed.

In addition, a bibliography of more than 150 publications pertaining to the biology of members of the genus *Botrychium* is included as an appendix.

BUREAU OF ENDANGERED RESOURCES
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707
608/266-7012
1997

Distribution, Current Population Status, Growth and Habitat of Goblin Fern (*Botrychium mormo*) in Wisconsin

William E. Tans and Dreux J. Watermolen
Bureau of Integrated Science Services
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707-7921
(608) 266-3524 / (608) 266-8931
tansw@dnr.state.wi.us / waterd@dnr.state.wi.us

Abstract: The Goblin Fern (*Botrychium mormo*), a seldom-encountered and little known plant, appears sporadically in second growth sugar maple-basswood forests in Minnesota, northern Wisconsin, and Michigan's Upper Peninsula. Goblin Fern is currently listed as endangered in Wisconsin. In this report, we review known distribution and current population status of Goblin Fern. Preliminary observations on growth and habitat are reported and implications for conservation and management are discussed.

Contents

Introduction

Goblin Fern (*Botrychium mormo* Wagner), also known as Little Goblin, Goblin Moonwort or Goblin Grape Fern, is a seldom-encountered and little known, tiny native fern (Fig. 1). Goblin Fern was recognized and formally described as a new species by Wagner and Wagner (1981), who had observed it for many years in the field prior to describing it as a new species. It was added to Wisconsin's endangered species list in April 1985, based on the lack of current and historical collections in the state. Before 1994, Goblin Fern was known in Wisconsin only from three historical collection sites in Ashland, Forest and Wood counties (Peck 1980, Wagner and Wagner 1981) and three other northern sites (Trick 1994). It is now thought to be extirpated from all three historical sites. Today, after focused searches in several northern Wisconsin counties and on national forest lands, we know Goblin Fern occurs in at least 55 locations. In this paper, we review its known distribution and current population status in Wisconsin. We also report our preliminary observations on growth and habitat and discuss implications for conservation and management of the species.

Methods

We conducted intensive monitoring of four Goblin Fern populations over a 3-year period. The study followed surveys for Goblin Fern populations completed by consulting botanists working for the Crandon Mining Company. For the purposes of this study, we defined a "site" or "population" as one or more Goblin Fern plants in an area at least 500 feet away from its nearest Goblin Fern neighbor. Plant location information was entered into Wisconsin's Natural Heritage Inventory.

In 1995, we began monitoring four Goblin Fern populations on and near the proposed Crandon Mining Company project site in northeastern Wisconsin, permanently marking the locations of 50 plants in the fall. To mark individual plants, we placed aluminum stakes containing numbered tags 2 centimeters to the north of each visible stem. Monitoring has continued through 1997, and we marked an additional 150 plants in the four populations during this time.

We transplanted several soil "plugs" containing one to four healthy Goblin Ferns in the fall of 1996. Each plug was approximately 0.3 m in diameter, 8-10 cm thick, and consisted of the humus/root layer from the forest floor overlying the mineral soil. The plugs were moved several miles from one Goblin Fern population to an area adjacent to another existing population. Each transplanted plant was permanently marked with a numbered stake to facilitate future monitoring.

Species Identification

Goblin Ferns are recognized by their persistent gametophytes, extremely succulent texture, and peculiar shiny yellow-green color, all of which appear to be genetically fixed (Wagner and Wagner 1981). The trophophore (leaf) is highly variable. In larger, mature plants, the

leaf blade bears two or three pairs of small blunt lobes. The entire blade may be absent in smaller plants. Rarely, on some of the larger, more robust plants, we observed the deeply embedded sporangia extending down the sporpophore (fertile segment) onto the trophophore.

Some small leaves of Goblin Fern may resemble those of Least Moonwort (*B. simplex*). That species, however, is found in dry fields, bogs, swamps, roadside ditches, and open, marshy habitats (Wagner and Wagner 1981, 1993) and has not been found growing with Goblin Fern (Wagner and Wagner 1983).

When the Goblin Fern was rediscovered in Wisconsin by the consulting botanists, several specimens were collected and sent to W.H. Wagner at the University of Michigan for identification. Later, we collected live material and sent it to D.R. Farrar at Iowa State University. Both confirmed the plants as Goblin Fern.

Distribution

Goblin Fern is endemic to the western Great Lakes region, ranging across the northern portions of Michigan, Wisconsin and Minnesota. Figure 2 shows the counties of occurrence for Goblin Fern. The plant has been collected from 11 sites in eight counties in Michigan (Penskar and Higman 1996; M. Penskar, pers. comm.). Many of these collections were made in the 1950s; there is no available information on the plant's current status at most of the original Michigan collection sites. In Minnesota, Goblin Fern is known from seven counties containing at least 96 sites, 87 of which occur within the Chippewa National Forest (J. Casson, pers. comm.). Many of these locations have been discovered since 1992, and in the last two years, the number of known populations in Minnesota has nearly doubled following intensive searching.

Habitat

In northern Wisconsin, Goblin Fern has been found exclusively in second growth, deciduous, mesic hardwood forests dominated by sugar maple (*Acer saccharum*) and basswood (*Tilia americana*), typically associated with white ash (*Fraxinus americana*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*) and hop hornbeam (*Ostrya virginiana*). It is not known from coniferous forests, swamps or lowlands, or aspen- or birch-dominated forests, but instead always occurs in the several-inch-deep leaf mold on the floor of sugar maple stands. Many of the sites where we have found Goblin Fern have a gray silty clay or sandy clay layer, underlain by a light gray silt or silty sand. Typically, the sites are situated on drumlins or morainal topography in the Superior Upland Province (Paull and Paull 1977).

We did not estimate the age of Wisconsin forest stands where Goblin Fern occurs, but do note that these stands vary in age structure. This observation is similar to observations of stands made in Minnesota. In that state, Gallagher (1995) found a mean stand age of 80 years old (+/- 23 years; range: 17-140 years old), with only two stands younger than 54 years old.

A number of understory plants typical of northern mesic forests are common associates of Goblin Fern (Table 1). Peck (1980) noted 31 other pteridophytes present at one Goblin Fern site. Other grapeferns we have found in similar habitats as Goblin Fern in Wisconsin include Rattlesnake Fern (*B. virginianum*), Triangle Moonwort (*B. lanceolatum*), Daisy-leaf Moonwort (*B. matricariifolium*), and Dissected Grapefern (*B. dissectum*). Wagner and Wagner (1981) also reported finding Common Moonwort (*B. lunaria*) and Leather Grapefern (*B. multifidum*) with Goblin Fern on rare occasions.

Growth Habit

Goblin Fern grows to a height of from only several centimeters to about 12 centimeters tall, making it very difficult to find on the forest floor. In fact, Goblin Fern has been cited as the smallest known North American moonwort (Lellinger 1985). Some of the smaller Goblin Fern plants, with stems 1-2 mm thick, barely protrude from beneath the leaf litter, while others remain below.

Goblin Fern has been referred to as a "mycorrhizal" species that is extremely dependent on moisture availability (TNC 1995). Plentiful spring and summer rains appear to yield abundant Goblin Fern populations. Reportedly, during dry periods, Goblin Ferns do not emerge above the leaf litter (Wagner and Wagner 1981, Penskar and Higman 1996). Our own observations confirm that during dry periods some plants die back and that new plants do not appear as frequently. Especially at these times, one must scrape away the leaf litter at known population sites to find any of the dwarfed, pale plants. In addition, other effects of the environment on growth habits can be profound. In the subgenus *Botrychium*, dry sites produce stalks that are much elongated and the sterile segments are reduced (Wagner and Wagner 1983).

Wagner and Wagner (1981) found that very small plants less than 1.5 cm tall often dominate a population. In addition, for every plant observed above ground, there may be numerous plants below ground or beneath the leaf litter that have not emerged. For example, when we excavated two large plants growing close together, we found 10 other sporophytes in various degrees of development. Most of these were completely underground. The below-ground juveniles range from sporophytes with their developing rootlets and "shoots" only a few mm long (Fig. 3) to sub-emergent plants above the soil surface but below the leaf litter. It is unknown for how many years juvenile plants can survive underground or the conditions that must occur for the plants to emerge and begin photosynthesis.

Other botanists have noted that the deeply embedded capsules of Goblin Fern fail to open (Wagner and Wagner 1993, TNC 1995). On mature plants, however, we observed that at least some of the capsules dehisce and release a miniature yellow-brown spore cloud when bumped. We confirmed this observation by examining individual sporophores under a dissecting microscope and noting the transverse slit and loose spores.

While spores are not believed to be wind dispersed, as they are in other species within the genus (TNC 1995), our observations support wind as a dispersal agent. However,

reproduction appears highly aggregated, suggesting that spores disperse very short distances. In places where there are one or two plants one year, there may be 4-10 plants the next, assuming growing conditions are adequate.

Phenology

We have observed Goblin Ferns in Wisconsin emerging from the leaf litter primarily in July and August, but individual plants may emerge from late June until after the first fall frost. The earliest plants appear well before the mid-August emergence reported for northern Michigan (Penskar and Higman 1996). The largest number of plants are visible at any given Wisconsin population from mid-July through August. This is slightly later than the maximum numbers observed in late June and mid-July in Minnesota populations (Johnson-Groh 1997). Through natural plant senescence, Goblin Fern populations numbers dwindle markedly beginning in mid-September. In October, when many are covered with the falling autumn leaves, and frosts have occurred, it is mostly the largest Goblin Fern plants that remain. This, along with the delayed or sporadic emergence, and the plants' diminutive size, makes censusing Goblin Fern populations difficult unless repeated visits are made to the same site.

Johnson-Groh (1997) reported that Goblin Fern plants in Minnesota emerged throughout June. She did not define emergence, however, and we are uncertain if the plants were counted if they had only emerged from the humus layer or if they were visible above the leaf layer.

Our preliminary observations on the longevity of Goblin Fern suggest that it is a short-lived, perennial plant. Of the initial 50 plants we permanently marked in the fall of 1995, seven (14%) never reappeared in the following two years, while 16 plants (32%) reappeared only in the first of the two following years. Twenty-five plants (50%) reappeared in both of the following growing seasons. Surprisingly, two plants of the original 50 marked in 1995 did not emerge again in 1996, but reappeared in 1997. This suggests that some plants may skip a year if environmental conditions are less than ideal. However, additional information is needed to confirm this.

Population Status and Monitoring

Goblin Fern is not as rare in Wisconsin as we believed only a few years ago. During field searches in 1994, consulting botanists working for the Crandon Mining Company located 14 populations of Goblin Fern on the proposed project site and adjacent lands in Forest County. In 1995, additional searches discovered nearly 30 additional populations in several new counties. Concurrently, botanists surveying the Nicolet and Chequamegon National Forests located several additional populations of Goblin Fern.

In searching for Goblin Ferns, pre-screening potential habitats resulted in eliminating many potential sites that appeared to be less than ideal habitat. Subsequent focused searches were successful on one out of every three sites examined. This was unexpected given that Wagner and Wagner (1981) estimated that only one in fifty seemingly suitable sites yielded specimens.

In northern Wisconsin, there are tens of thousands of acres of maple-basswood forests similar to those in which we have observed Goblin Ferns, but which have not been surveyed for the plant. Based on our field experience searching for Goblin Fern, we suspect there are a large number of additional sites where Goblin Fern actually occurs in the state and expect the plant to occur much more frequently than existing data indicate.

The smaller Goblin Ferns that have emerged from the leaf litter appear sensitive to drought conditions. This is not surprising since the entire above ground plant is contained in the several-centimeter deep humus layer composed primarily of maple leaves in various stages of decomposition. Smaller plants may senesce after only several weeks if moisture conditions are inadequate. Larger, stouter plants seem less affected by temporary lack of moisture. Wagner and Wagner (1993) described the highly seasonal appearance of Goblin Fern as being more like a fungus carpophore than a moonwort. Sensitivity to moisture conditions probably explains why population numbers fluctuated from the "thousands" of plants seen in one population in the state in the late 1970's to only a few plants at the same site several years later.

In addition to drought, a variety of other factors may affect Goblin Fern populations. For example, other authors have suggested that the succulent nature of the plant may make it attractive to small herbivores (Wagner and Wagner 1993). Our observations confirm this. The tips and leaves of several plants at our study sites had been nibbled off. Microtine rodents and a variety of herbivorous arthropods are abundant at the sites and are likely responsible for the feeding damage we observed. Our observations suggest a similar conclusion to Johnson-Groh's (1995) -- that herbivory does not appear to adversely affect Goblin Fern populations. However, Johnson-Groh and Farrar (1996) suggest that leaf loss from herbivory combined with environmental events such as fire or drought could result in a loss of vigor or population decline of *Botrychium* species found in prairies. Additional field observations could further elucidate the impacts of herbivory, if any, on Goblin Fern.

Conservation and Management

Devising adequate conservation and management strategies for Goblin Fern is difficult, due in part to our lack of knowledge (Penskar and Higman 1996). Observations from our monitoring work, however, have several conservation and management implications which we outline here.

Effects of Logging: Logging and associated physical disruption of the mature forest habitat is believed to be a potential threat to Goblin Fern (TNC 1995). Since Goblin Fern seems to be sensitive to the effects of drought, any activity that opens the forest canopy and exposes the leaf litter and humus layer to desiccation could potentially be detrimental to the species.

During the course of our study, three of the maple forests containing populations of Goblin Fern that we were monitoring were selectively cut. Preliminary observations suggest that this type of logging may have little impact on Goblin Fern persistence, assuming that the plants

are not directly destroyed by the activity. Selective logging that we observed removed only part of the maple overstory canopy. As a result, mostly shaded rich, moist humus in which the Goblin Ferns grow appears to have been unaffected by this activity. More intensive cutting could, however, significantly open the canopy and result in desiccation of the humus layer, or on steeper slopes, result in erosional impacts. The effects of current forest management activities should be assessed, and as Johnson-Groh (1995) suggests, the role of disturbance in the biology of Goblin Fern should be determined.

In the meantime, we suggest leaving a minimum buffer zone of approximately 200-250 feet around each known Goblin Fern population. A buffer zone of this size represents a distance of about 2-3 times the canopy tree height, which should be adequate to prevent significant environmental changes to the forest floor humus and protect the plants.

Transplantation: Wagner and Wagner (1983) found *Botrychium* plants difficult to grow and attributed this to their "delicately attuned mycorrhizal relationships." While this is true if attempting to grow ferns from spores in the laboratory or greenhouse, we have not found this to be the case with our transplants in forest habitats. Transplanted individuals have shown approximately the same success in emerging during the summer of 1997 as did the naturally emerging plants we observed. We attribute this, at least in part, to the relocation of the underlying humus along with the plants.

During the transplantation work we unknowingly and unexpectedly transplanted numerous juvenile plants that had not emerged from the soil humus at the time of transplanting. The following summer, we observed 12 additional plants among those in the transplanted soil plugs. It is also possible that the additional plants developed from spores dropped by the transplanted individuals. We are cautiously optimistic that transplanting Goblin Ferns will be successful over the long-term and hope to monitor individual transplants through several additional seasons.

Monitoring: A number of authors have pointed out the difficulty associated with monitoring Goblin Fern populations. Plants are difficult to locate and they may not emerge during dry periods. Due to the periodic emergence of this species, many populations may have been overlooked during previous inventory attempts.

We agree with Wagner and Wagner's (1983) recommendation to the field worker who discovers a single *Botrychium*: Look around! Almost invariably, more individuals will be found. On occasion, a careful search will reveal hundreds of individuals. Johnson-Groh (1995) correctly noted that it is imperative to search beneath the litter in addition to surveying for emergent plants in order to accurately assess population size.

Future monitoring efforts on public lands should be directed at surveys to identify extant population in areas of planned management activities.

Existing Protection of Populations: In the three states where Goblin Fern occurs, the majority of known populations are within national forests. In Wisconsin, 38 of the 55 existing sites (69%) occur on national forest lands. In Minnesota, about 90% (87 of 96) of the sites lie within national forests. Ownership of this type can provide a significant degree of protection to the species, especially when lands are managed with consideration for the species.

Acknowledgments

Mike Penskar of the Michigan Natural Features Inventory and John Casson of the Chippewa National Forest in Minnesota provided information on distribution in those states. Bob Queen took the photographs in Fig. 1, and Danielle Wood produced the map in Fig. 2. Ann Lacy assisted in identifying references for Appendix A. June Dobberpuhl commented on an early draft of the manuscript. We appreciate their assistance.

Literature Cited

Gallagher, J. 1995. In-house Memorandum (October 25, 1995) to P. Tennis, Subj.: Stand age and condition in Goblin Fern colonies. U.S.D.A. Chippewa Natl. Forest, Blackduck Ranger Dist., Blackduck, MN. 2 pp.

Johnson-Groh, C. 1995. Monitoring and life history of *Botrychium mormo* in Minnesota. Unpubl. Final Rept., Minnesota Dept. Natural Resources, St. Paul. 9 pp.

Johnson-Groh, C. 1997. Field surveys for *Botrychium gallicomontanum* and phenology of *Botrychium mormo* in Minnesota. Unpubl. Rept. 15 pp.

Johnson-Groh, C.L. and D.R. Farrar. 1996. Effects of leaf loss on moonwort ferns, *Botrychium* subgenus *Botrychium*. [abstract no. 358]. *American J. Bot.* 83(6):135.

Lellinger, D.B. 1985. A field manual of ferns and fern allies of the United States and Canada. Smithsonian Inst. Press, Wash. D.C. 389 pp.

Paull, R.K. and R.A. Paull. 1977. *Geology of Wisconsin and Upper Michigan, Including Parts of Adjacent States*. Kendall/Hunt Publ/ Co., Dubuque, IA. 232 pp.

Peck, J.H. 1980. Discovery of the Goblin Fern in Wisconsin. *Bull. Wisconsin Bot. Club* 12(2):2-4.

Peck, J.H. and W.C. Taylor. 1980. Check List and Distribution of Wisconsin Ferns and Fern Allies. *Michigan Botanist* 19: 251-268

Penskar, M.R. and P.J. Higman. 1996. Special plant abstract for *Botrychium mormo* (goblin moonwort). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

The Nature Conservancy. 1995. Element stewardship abstract for *Botrychium mormo*, Goblin fern. The Nature Conservancy, Arlington, VA. 6 pp.

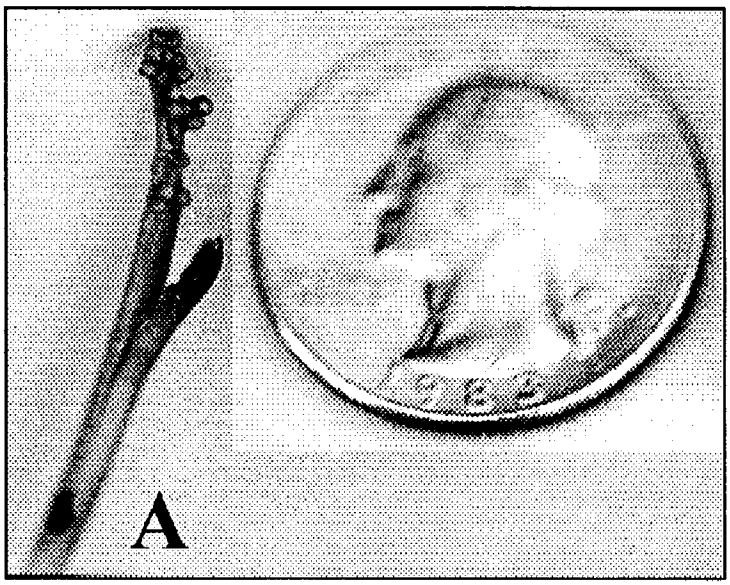
Trick, J.A. 1994. Report on the Status of the Goblin Fern *Botrychium mormo* W.H. Wagner in Wisconsin, 1993. Unpubl. Rept., U.S. Fish Wildl. Serv., Green Bay. 7 pp.

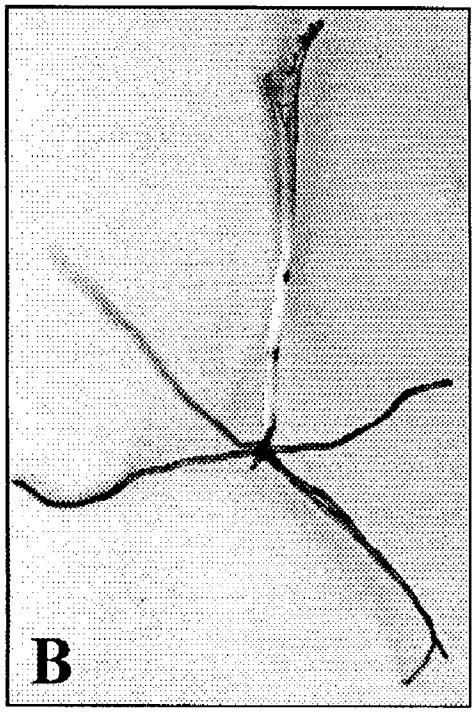
Wagner, W.H., Jr. and F.S. Wagner. 1981. New Species of Moonworts, *Botrychium* subg. *Botrychium* (Ophioglossaceae), from North America. *American Fern J.* 71(1):20-30.

Wagner, W.H., Jr. and F.S. Wagner. 1983. Genus communities as a systematic tool in the study of New World *Botrychium* (Ophioglossaceae). *Taxon* 32(1):51-63.

Wagner, W.H., Jr. and F.S. Wagner. 1993. Ophioglossaceae C. Agardh. Ader's Tongue Family. pp. 85-106 In *Flora of North America. Vol 2. Pteridophytes and Gymnosperms.* Oxford Univ. Press, New York. 475 pp.

Figure 1. The Goblin Fern: A) Detail of sporophore, shown with quarter for scale; B) Entire plant, showing rootlets and gemmule





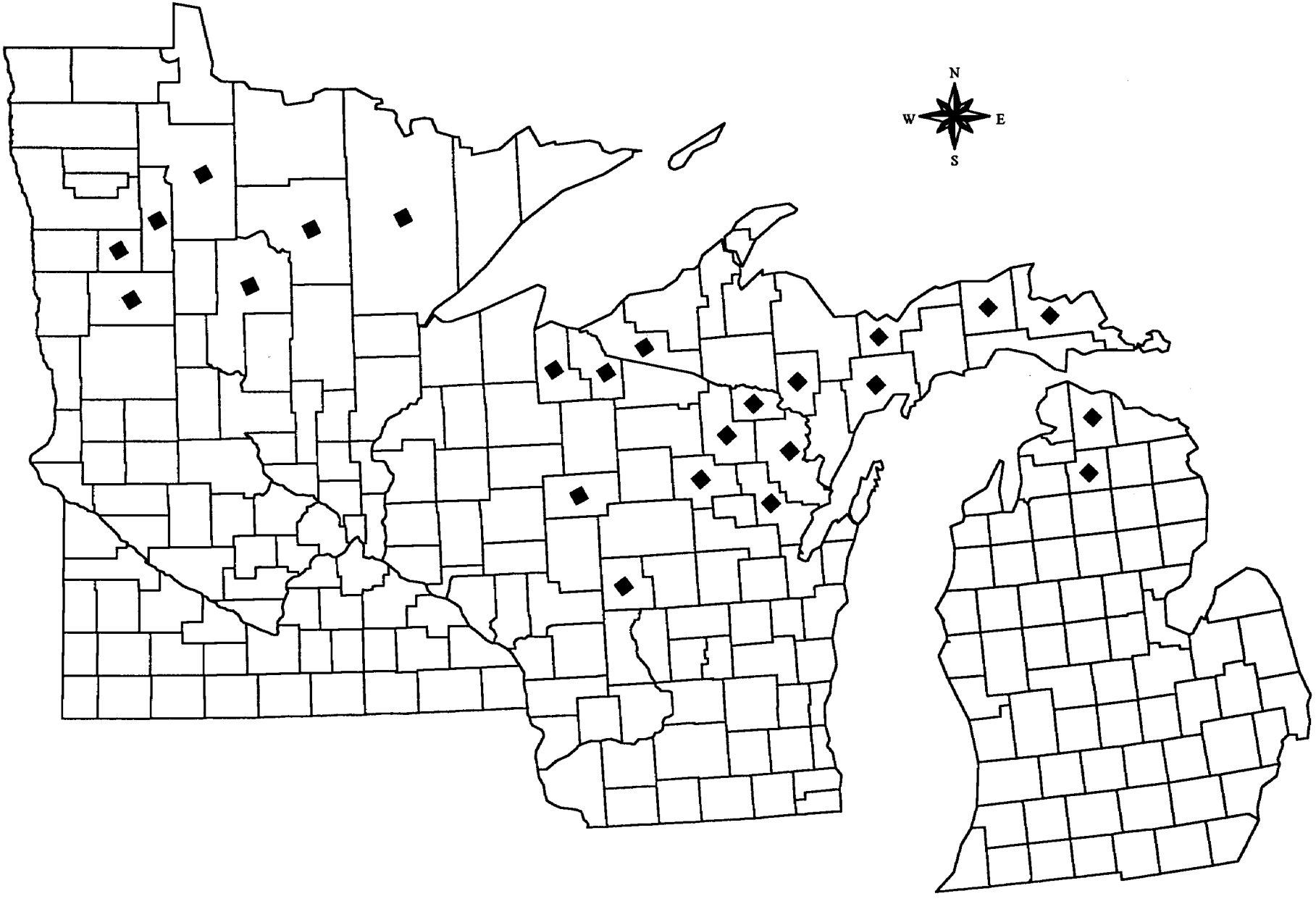


Figure 2. Known world distribution of Goblin Fern (as of September 1997)

Figure 3. Sporophytes with developing rootlets and "shoots." Scale bar = 1 cm.

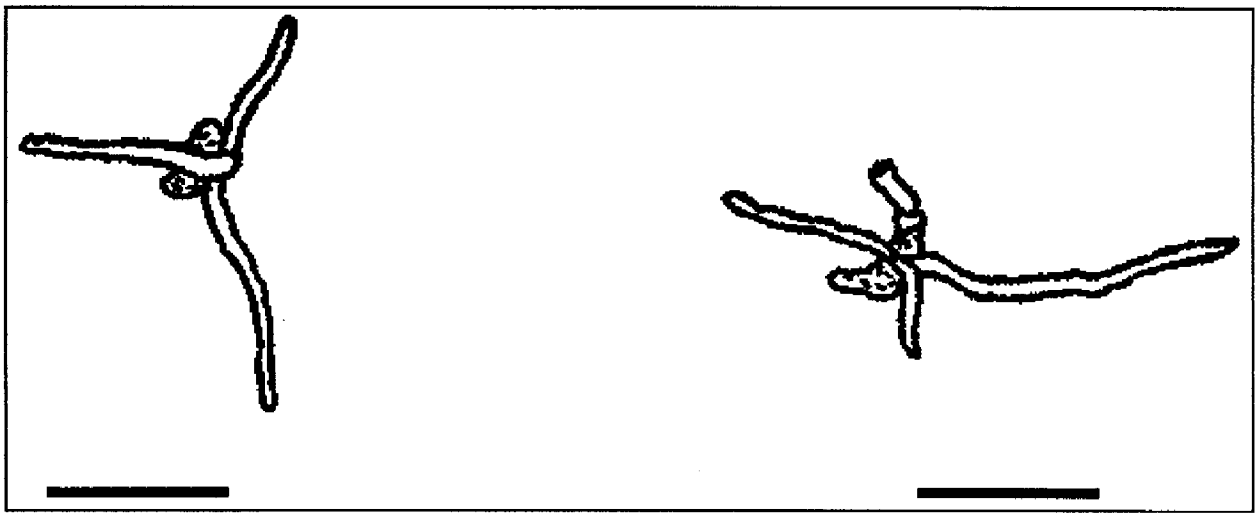


Table 1. Understory plants associated with Goblin Ferns in northern Wisconsin

Actaea rubra	Red Baneberry
Adiantum pedatum	Maidenhair Fern
Aralia racemosa	Spikenard
Aster macrophyllus	Big-leaved Aster
Carex pedunculata	Peduncled Sedge
Carex pensylvanica	Pennsylvania Sedge
Caulophyllum thalictroides	Blue Cohosh
Celastrus scandens	American Bittersweet
Claytonia caroliniana	Spring Beauty
Clinopodium vulgare	Wild Basil
Dicentra cucullaria	Dutchman's Breeches
Dirca palustris	Leatherwood
Dryopteris intermedia	Florist's Fern
Maianthemum canadense	Canada Mayflower
Monotropa uniflora	Indian Pipe
Osmorhiza claytoni	Hairy Sweet Cicely
Polygonatum pubescens	Downy Solomon's Seal
Sambucus pubens	Red Elder
Sanguinaria canadensis	Bloodroot
Trientalis borealis	Starflower
Trillium grandiflorum	Trillium
Uvularia grandiflora	Bellwort

Appendix A: *Botrychium* Bibliography

Works pertaining to the biology of *Botrychium* species and published since 1980 are listed below. A few older publications are included, and a number of references pertaining to the Ophioglossaceae -- but not specific to *Botrychium* -- are also included. The bibliography is intended to be comprehensive, but not exhaustive. A number of Ph.D. theses are included, but government agency and other unpublished reports have been omitted. References are listed alphabetically by author in standard journal format. Works are in English unless otherwise noted. *Note:* Citations have not been verified, and readers are encouraged to check the original work for accuracy before citing.

Ahlenslager, K and P. Lesica. 1996. Observations of *Botrychium* X *watertonense* and its putative parent species, *B. hesperium* and *B. paradoxum*. *American Fern J.* 86(1):1-7.

Alverson, E.R. and P.F. Zika. 1996. *Botrychium* diversity in the Wallowa Mountains, Oregon. (Abstract). *American J. Bot.* 83(6 Suppl.):123.

Asen, P.A. and J. Andreassen. 1980. New vascular plant records from Aust-Agder and Vest-Agder counties, south Norway: 7. *Blyttia* 38(4):215-220. [Norwegian]

Asker, S. 1993. Plant localities from the Storlien area, central Sweden. *Svensk Botanisk Tidskrift* 87(1):57-60. [Swedish]

Asker, S. 1994. Finds of vascular plants in the parish of Tannas, Harjedalen, C Sweden. *Svensk Botanisk Tidskrift* 88(6):363. [Norwegian]

Achuff, P.L. 1992. Status review of *Botrychium minganense*, U.S.D.A. Forest Service, Region 1, Lolo National Forest. Montana Nat. Heritage Prog., Helena. 26 pp.

Awasthi, D.K. and M.P. Sharma. 1980. Ecological and phytogeographical observations on the ferns and fern allies of Nagpur Block (Chamoli Garhwal), Western Himalayas, India. *Proc. Indian Acad. Sci. Plant Sci.* 89(4):307-314.

Berch, S.M. and B. Kendrick. 1982. Vesicular-arbuscular mycorrhizae of southern Ontario, Canada, ferns and fern-allies. *Mycologia* 74(5):769-776.

Bergeron, Y, A. Bouchard and G.N. Massicotte. 1978. Additions to the flora of Abitibi County, Quebec, Canada. *Naturaliste Canadien* (Quebec) 105(6):478-484. [French]

Bhambie, S and P. Madan. 1980. Pteridophytes: 17. Ontogenetic study on the shoot apex of *Botrychium lanuginosum*. *Proc. Indian Acad. Sci. Plant Sci.* 89(1):29-36.

Bhambie, S. and P. Madan. 1982. Observations on the venation patterns in *Ophioglossum, Botrychium* and *Helminthostachys*. *Fern Gazette* 12(4):215-223.

Bhardwaja, T.N., C.B. Gena and S. Varma. 1987. Status survey of pteridophytic flora of Rajasthan (India) with special reference to endangered ferns and fern allies. *Indian Fern J.* 4(1-2):47-50.

Bhavanandan, K.V. and L.S. Ammal. 1993. Studies on the spore morphology of some South Indian ferns. *Indian Fern J.* 10(1-2):12-16.

Bir, S.S. and S. Bhusri. 1985. Pteridophytic flora of Simla Hills (India) (Northwestern Himalayas), families: Equisetaceae, Selaginellaceae and Ophioglossaceae. *Indian Fern J.* 2(1-2):39-56.

Bir, S.S. and K. Randhawa. 1984 (1985). Studies on apical meristems in certain ferns. *Indian Fern J.* 1(1-2):11-29.

Bjorkback, F. 1989. A method for botanical inventorying and documentation adapted to national forest evaluation. *Fauna och Flora* (Stockholm) 84(3):130-137. [Swedish]

Blondeau, M and J. Cayouette. 1987. Extensions in distribution area in the vascular flora of New Quebec (Canada). *Naturaliste Canadien* (Quebec) 114(1):117-126. [French]

Borgstrom, B. 1994. *Salix myrtilloides*, *Botrychium virginianum* and *Blechnum spicant* in the province of Ostergotland, Sweden. *Svensk Botanisk Tidskrift* 88(1):31-32. [Swedish]

Braggins, J.E. 1980. Some studies on the New Zealand species of *Botrychium* (Ophioglossaceae). *New Zealand J. Bot.* 18(3):353-366.

Brande, A. 1980. Pollen-analytical studies in the late glacial and early postglacial period of Berlin (East Germany). *Verhandlungen des Botanischen Vereins der Provinz Brandenburg* 115(0):21-72. [German]

Camacho, F.J. 1996. New report of subterranean sporophytic gemmae on *Botrychium pumicola*. *American Fern J.* 86(1):27-28.

Chau, R.I. 1981. Vascular morphology of the Ophioglossaceae. Ph.D. Thesis. Univ. Michigan, Ann Arbor.

Chau, R.I. 1985. Vascular connection between lateral roots and stem in the Ophioglossaceae. *American J. Bot.* 72(9):1475-1482.

Chau, R.I. 1986. Xylem structure in *Botrychium dissectum* Sprengel and its relevance to the taxonomic position of the Ophioglossaceae. *American J. Bot.* 73:1201-1206.

Chechetkin, E.V. 1986. A supplement to the flora of the Stanovoi Range (Russian SFSR, USSR). *Botanicheskii Zhur.* (St. Petersburg) 71(11):1562-1564. [Russian]

Chechetkin, E.V. 1989. On some new and rare plant species for the northern Transbaikal Region (Russian SFSR, USSR). *Botanicheskii Zhur.* (Leningrad) 74(7):1051-1054. [Russian]

Chechetkina, L.G. 1990. Floristic findings in northern Transbaikalia (Russian SFSR, USSR). *Botanicheskii Zhur.* (Leningrad) 75(10):1455-1458. [Russian]

Daigobo, S. 1979. Gametophytes of *Botrychium multifidum* from nature. *J. Japanese Bot.* 54(6):169-177.

Daigobo, S. 1983. Endophytic fungi in the gametophyte of *Botrychium multifidum*. *J. Japanese Bot.* 58(6):178-184. [Japanese]

Do, L.H., R.D. Gooch, J.R. Stevens, W.C. Holmes and J.R. Singhurst. 1996. New county records of *Botrychium lunarioides* in Texas. *American Fern J.* 86(1):28-31.

Eisto, K. 1994. The occurrence and need for protection of *Botrychium virginianum* (L.) Swartz in the Oulu and Lapland provinces in Finland. *Aquilo Ser Botanica* 33(0)17-29. [Finnish]

Eriksson, G. and K. Kallstrom. 1994. The moonwort *Botrychium simplex* in Dalarna. *Svensk Botanisk Tidskrift* 88(1):48.

Faegri, K. 1995. Common names and superstition: A tour in unfamiliar terrain. *Blyttia* 53(3):159-160. [Norwegian]

Fahraeus, G. 1981. New finds of *Botrychium* spp. from Gotland, Sweden. *Svensk Botanisk Tidskrift* 75(2):97-101. [Swedish]

Farrar, D.R. 1985. Pteridophytes of Iowa's loess Hills - adaptations to dry habitats. *Proc. Iowa Acad. Sci.* 92:196-198.

Farrar, D.R. and C.L. Johnson-Groh. 1986. Distribution, systematics and ecology of *Botrychium campestre*, the prairie moonwort. *Missouriensis* 7:51-58.

Farrar, D.R. and C.L. Johnson-Groh. 1990. Subterranean sporophytic gemmae in moonwort ferns, *Botrychium* subgenus *Botrychium*. *American J. Bot.* 77:1168-1175.

Farrar, D.R. and C.L. Johnson-Groh. 1991. A new prairie moonwort (*Botrychium* subgenus *Botrychium*) from Northwestern Minnesota. *American Fern J.* 81(1):1-6.

Farrar, D.R., C.L. Johnson-Groh, N.R. Lersten and W.H. Wagner, Jr. 1986. Subterranean sporophytic gemmae in *Botrychium* subg *Botrychium*. *American Fern J.* 73(5):735-736.

Farrar, D.R. and J.F. Wendel. 1996a. On the relationships of the *Botrychium matricariifolium* complex in eastern North America. (Abstract). *American J. Bot.* 83(6 Suppl.):125.

Farrar, D.R. and J.F. Wendel. 1996b. Eastern moonworts: Genetics and relationships. (Abstract). *American J. Bot.* 83(6 Suppl.):124.

Fernandez, H., A.M. Bertrand and R. Sancheztames. 1997. Gemmation in cultured gametophytes of *Osmunda regalis*. *Plant Cell Repts.* 16(5):358-362.

Foster, D.B. 1964. The gametophytes and embryogeny of five species of *Botrychium*. Ph.D. Thesis. Cornell Univ., Ithaca.

Fotedar, R.L and S.S. Bir. 1980 (1981). Structure of phloem in two members of Ophioglossaceae from India. *Phytomorph.* 30(2-3):164-172.

Gaddy, L.L. 1990. Glade Fern Ravine, a rich fern site in the Blue Ridge province of South Carolina (USA). *Castanea* 55(4):282-285.

Genberg, E. 1981. The flora of Ostergotland, Sweden: Additions and corrections: 2. *Svensk Botanisk Tidskrift* 75(3):163-166. [Swedish]

Gifford, E.M., Jr. and D.D. Brandon. 1978. Gametophytes of *Botrychium multifidum* as grown in axenic culture. *American Fern J.* 68(3):71-75.

Graham, D.A. and W.H. Wagner. 1991. An exceptional leaf of *Botrychium dissectum*. *American Fern J.* 81(3):103-105.

Greller, A.M. 1985. A vascular flora of the forested portion of Cunningham Park, Queens County, New York (USA): Corrections and additions: II. *Bull Torrey Bot. Club* 112(3):312.

Harley, J.L. and S.E. Smith. 1983. *Mycorrhizal symbiosis*. Academic Press, London.

Hauk, W.D. 1995. A molecular assessment of relationships among cryptic species of *Botrychium* subgenus *Botrychium* (Ophioglossaceae). *American Fern J.* 85(4):375-394.

Hauk, W.D. 1996. Phylogenetics of Ophioglossaceae: The evolutionary consequences of morphological reduction. Ph.D. Thesis. Univ. North Carolina, Chapel Hill.

Ho, L.H., R.D. Gooch, J.R. Stevens, W.C. Holmes and J.R. Singhurst. 1996. New county records of *Botrychium lunarioides* in Texas. *American Fern J.* 86(1):28-31.

Holmes, W.C., T.L. Morgan, J.R. Stevens, R.D. Gooch andJ.R. Singhurst. 1996. Comments on the distribution of *Botrychium lunarioides* (Ophioglossaceae) in Texas. *Phytologia* 80(4):280-283.

Hong, S.S. and W.Y. Soh. 1993 (1994). Vascular meristem and secondary growth in the rhizome of *Botrychium ternatum*. *Phytomorph.* 43(3-4):251-260.

Horn, K and A.M. Stoor. 1995. Plant collecting versus species protection: Three case examples. *Berichte der Bayerischen Botanischen Gesellschaft zur Erforschung der Heimischen Flora* 65(0):143-146.

Hrouda, L., J. Kochjarova and K. Marhold. 1990. The flora of the Mt. Kralova hola (Slovakia, Czechoslovakia). *Preslia* (Prague) 62(2):139-162. [Czech]

Imaichi, R. 1989. Early leaf development and leaf sheath formation of *Botrychium strictum* and *B. virginianum* (Ophioglossaceae). *Annals Bot.* (London) 63:249-256.

Imaichi, R and M. Nishida. 1986. Developmental anatomy of the three-dimensional leaf of *Botrychium ternatum*. *Bot. Mag. Tokyo* 99(1053):85-106.

Imaichi, R and N. Sahashi. 1991. An anomalously dichotomous rhizome of *Botrychium ternatum* (Ophioglossaceae). *Bull. Faculty Agric. Tamagawa Univ.* 0(31):11-16.

Iversen, J.I. 1990. Extinct vascular plant species in Ostfold, southeast Norway, including presumed misinterpretations during the last 200 years. *Blyttia* 48(3):137-144.

Johnson-Groh, C.L. and D.R. Farrar. 1993. Population dynamics of prairie moonworts *Botrychium* subgenus *Botrychium* in Iowa and Minnesota. (Abstract) *American J. Bot.* 80(6 Suppl.):109.

Johnson-Groh, C.L. and D.R. Farrar. 1996a. The effects of fire on prairie moonworts (*Botrychium* subgenus *Botrychium*) (Abstract). *American J. Bot.* 83(6 Suppl.):134.

Johnson-Groh, C.L. and D.R. Farrar. 1996b. Effects of leaf loss on moonwort ferns (*Botrychium* subgenus *Botrychium*) (Abstract). *American J. Bot.* 83(6 Suppl.):127.

Johnson-Groh, C.L., D.P. Whittier and D.R. Farrar. 1996. Ecological adaptations of mycorrhizal obligate ferns. (Abstract). *American J. Bot.* 83(6 Suppl.):121.

Karlsson, T. 1988. Floristic notes. *Svensk Botanisk Tidskrift* 82(2):157-158. [Swedish]

Karlsson, T. 1990. Floristical notes. *Svensk Botanisk Tidskrift* 84(4):246-249. [Swedish]

Kartesz, J.T. and K.N. Gandhi. 1995. Nomenclatural notes for the North American flora: XIV. *Phytologia* 78(1):1-17.

Kaynak, G amd O.N. Tuyji. 1991. Chorological investigations on the ferns of Bursa (Turkey) and its surroundings. *Doga Turk Botanik Dergisi* 15(2):227-235. [Turkish]

Kelly, D. 1994. Demography and conservation of *Botrychium australe*, a peculiar, sparse mycorrhizal fern. *New Zealand J. Bot.* 32(4):393-400.

Kerger, M.T., G.H. Parent and D. Thoen. 1994. Chorological and ecological notes on the vascular flora of the Province of Luxembourg (Belgium) and limitroph regions. *Lejeunia* 0(145):1-86. [French]

Khandelwal, S. 1986. The morphological nature of the fertile spike in the Ophioglossaceae. *Bot. J. Linnean Soc.* 92(2):89-94.

Khokhryakov, A.P. 1988. The new adventive and mild species of pteridophyte of the Adzhar ASSR (Georgian SSR, USSR). *Biologicjeskie Nauki* (Moscow) 0(8):67-68. [Russian]
Kvavadze, E.V. and A.K. Vekua. 1993. Vegetation and climate of the Dmanisi man period (East Georgia) from palynological data. *Acta Palaeobot.* 33(2):343-355.

Lee, K.B. and W.Y. Soh. 1995a. Comparative anatomy and ultrastructure of active and dormant vascular cambium in rhizome of *Botrychium ternatum*. *J. Plant Res.* 108(1090):149-159.
Lee, K.B. and W.Y. Soh. 1995b. Ultrastructure and histochemistry of determinate vascular cambium in rhizome of *Botrychium ternatum*. *J. Plant Biol.* 38(1):115-119. [Korean]
Lesica, P. and K. Ahlenslager. 1996. Demography and life history of three sympatric species of *Botrychium* subg. *Botrychium* in Waterton Lakes National Park, Alberta. *Canadian J. Bot.* 74(4):538-543.
Levin, G and R. Moran. 1989. The vascular flora of Isla Socorro, Mexico. *San Diego Soc. Nat. Hist. Memoirs* 0(16):1-71.
Levy, F., V. King, C. Ousley, T. Phillips and D. White. 1983. The ferns and fern allies of Pike County, Kentucky (USA). *Trans. Kentucky Acad. Sci.* 44(1-2):14-16.
Lindstrom, H. 1980. Remnants of hay-meadow vegetation in the province of Medelpad, East Central Sweden. *Svensk Botanisk Tidskrift* 74(4):281-294. [Swedish]

Madan, P. and S. Bhambie. 1980. Tracheary elements in Ophioglossaceae. *Feddes Repertorium* 91(5-6):301-307.
Manhart, J.R. 1995. Chloroplast 16S rDNA sequences and phylogenetic relationships of fern allies and ferns. *American Fern J.* 85(4):182-192.
Manickam, V.S. 1984. Cytology of thirty species of ferns from the Palni Hills (South India). *Cytologia* (Tokyo) 49(1):49-60.
Martini, F. and L. Poldini. 1991. Floristic signalling from Friuli-Venezia Giulia Region IV (47-65). *Gortania Atti del Museo Friulano di Storia Naturale* 13(0):137-156. [Italian]
Mason, N.A. and D.R. Farrar. 1989. Recovery of *Botrychium* gametophytes, gemmae, and immature sporophytes by centrifugation. *American Fern J.* 79(4):143-145.
McCauley, D.E., D.P. Whittier and L.M. Reilly. 1985. Inbreeding and the rate of self-fertilization in a grape fern, *Botrychium dissectum*. *American J. Bot.* 72:1978-1981.
McIlraith, A.L. 1986. Additions to the vascular flora of Kent Island, New Brunswick (Canada). *Rhodora* 88(856):441-444.
Melan, M.A. 1985. Morphological and physiological changes in spores of *Botrychium dissectum forma obliquum* during germination. Ph.D. Thesis. Venderbilt Univ., Nashville.
Melan, M.A. and D.P. Whittier. 1986. Characterization of mucilage rings found on the proximal cells of two-Celled gametophytes of *Botrychium dissectum* (Abstract). *American J. Bot.* 73(5):738-738.
Melan, M. and D.P. Whittier. 1989. Characterization of mucilage on the proximal cells of young gametophytes of *Botrychium dissectum* (Ophioglossaceae). *American J. Bot.* 76(7):1006-1014.

Melan, M.A. and D.P. Whittier. 1990. Effects of inorganic nitrogen sources on spore germination and gametophyte growth in *Botrychium dissectum f. obliquum*. *Plant Cell & Environ.* 13(5):477-482.

Moen, A. 1990. The plant cover of the boreal uplands of Central Norway: I. Vegetation ecology of Solendet Nature Reserve: Haymaking fens and birch woodlands. *Gunneria* 0(63):1-451.

Montgomery, J.D. 1990. Survivorship and predation changes in five populations of *Botrychium dissectum* in eastern Pennsylvania. *American Fern J.* 80(4):173-182.

Muller, S. 1986. *Botrychium matricariifolium* in the sandy lawns of the area around Bitche (North of the Vosges Mountains) (France). *Bull. de la Soc. Botan. de Frances Letts. Botan.* 133(2):189-198.

Muller, S. 1991. The phytocenosis with *Botrychium matricariifolium* (Retz) A. Br. in the Bitcherland (Northern Vosges, France): Application to conservatory management of this species. *Bull. de la Soc. Botan. de France Actual. Botan.* 138(2):147-158. [French]

Muller, S. 1992. The impact of a drought in spring on the sporulation of *Botrychium matricariifolium* (Retz) A. Br. in the Bitcherland (Northern Vosges, France). *Acta Oecologica* 13(3):335-343.

Muller, S. 1993. Population dynamics in *Botrychium matricariifolium* in Bitcherland (northern Vosges Mountains, France). *Belgian J. Bot.* 126(1):13-19.

Muller, S. 1994 (1995). Sandy dunes plant communities in Bitcherland (Northern Vosges): Biogeographical origin and conservation problems. *Acta Botanica Gallica* 141(6-7):761-768. [French]

Nazimova, D.I. and N.V. Stepanov. 1988. New and rare species for the flora of the Krasnoyarsk Krai (Russian SFSR, USSR). *Botanicheskii Zhur.* (Leningrad) 73(12):1761-1763. [Russian]

Nekola, J.C. and D.W. Schlicht. 1996. Distribution of *Botrychium campestre* in northeastern Iowa. *American Fern J.* 86(4):119-123.

Nekola, J.C. and D.W. Schlicht. 1997. Ecology of *Botrychium campestre* on northeastern Iowa glades. *Prairie Naturalist* 28(2):77-__.

Nilsson, O. and L.A. Gustafsson. 1979. Report from project Linnaeus: 106-120. *Svensk Botanisk Tidskrift* 73(5):353-372. [Swedish]

Pande, P.C. and Y.P.S. Pangtey. 1987. Studies on ethnobotany: I. On some less known edible and economic ferns of Kumaun region of western Himalaya (India). *J. Econ. Taxon. Bot.* 11(1):81-86.

Pant, D.D., D.R. Misra and A.K. Shukla. 1993. Tracheary elements and occurrence of vessels in Pteridophytes: I. Ophioglossaceae. *Bionature* 13(2):107-126.

Peck, J.H. 1980. Life history and reproductive biology of the ferns of Woodman Hollow, Webster County, Iowa. Ph.D. Thesis. Iowa State Univ., Ames.

Peck, J.H. 1989. Additions to the Iowa (USA) pteridophyte flora: III. *J. Iowa Acad. Sci.* 96(2):54-56.

Peroni, A. and G. Peroni. 1993 (1995). *Botrychium matricariifolium* (Retz.) Braun ex W. Koch in Prealps of the province of Varese (Lombardy, NW Italy). *Atti della Societa Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano* 134(1): 25-32. [Italian]

Persson, S. 1983. A *Botrychium* locality in Medelpad, Sweden. *Svensk Botanisk Tidskrift* 77(2):87. [Swedish]

Pettersson, O. 1981. The flora on a local outcrop of lime in north Ostergotland, Sweden. *Svensk Botanisk Tidskrift* 75(2):93-95. [Swedish]

Pittillo, J.D. and A.E. Brown. 1988. Additions to the vascular flora of the Carolinas (USA): III. *J. Elisha Mitchell Sci. Soc.* 104(1):1-18.

Pryadko, O.I. 1982. Floristic finds in the area of the proposed Dnieper Natural Park (Ukrainian SSR, USSR). *Ukrayins'kyi Botanichnyi Zhur.* 39(5):93-96. [Ukrainian]

Pryer, K.M., A.R. Smith and J.E. Skog. 1995. Phylogenetic relationships of extant ferns based on evidence from morphology and rbcL sequences. *American Fern J.* 85(4):205-282.

Radzhi, A.D. 1986. New and rare plants in the flora of the Dagestan ASSR (USSR). *Botanicheskii Zhur.* (St. Petersburg) 71(8):1134-1135. [Russian]

Rakov, N.S. and A.Y. Pchelkin. 1980. Floristic finds in Ulyanovsk Oblast, Russian SFSR, USSR. *Botanicheskii Zhur.* (St. Petersburg) 65(5):711-713. [Russian]

Raubeson, L.A. 1991. Structural variation in the chloroplast genome of vascular land plants. Ph.D. Thesis. Yale Univ., New Haven.

Reed, C.F. and E.C. Hadaway. 1994. Ferns on fossiliferous Eocene formations in Maryland. *American Fern J.* 84(4):132-133.

Regula-Bevilacqua, L. 1986. Some rare plants in the flora of Strahinscica mountain (Yugoslavia). *Acta Bot. Croatica* 45(0):145-152. [Serbo-Croatian]

Ronginskaya, A.V. and O.B. Kazantseva. 1982. Seasonal dynamics of reserves of epigeal phytomass in tall herb communities of the Salair mountain range (Russian SFSR, USSR). *Ekologiya* (Moscow) 0(3):1-5. [Russian]

Root, P.G. and J.D. Montgomery. 1987. *Botrychium pinnatum* in Colorado. *American Fern J.* 77(2):68-69.

Rothwell, G.W. and R.A. Stockey. 1989. Fossil Ophioglossales in the Paleocene of western North America. *American J. Bot.* 76(5):637-644.

Salo, K. 1986. Kivatsu, nature reserve in the Karelian SSR (USSR). *Luonnon Tutkija* 90(2):100-106. [Netherlandish]

Sanda, V. 1992. Distribution of Ophioglossaceae species in the flora of Romania. *Studii si Cercetari de Biologie Ser. Biol. Vegetala* 44(1):3-13. [Romanian]

Schmid, E. and F. Oberwinkler. 1994. Light and electron microscopy of the host-fungus interaction in the achlorophyllous gametophyte of *Botrychium lunaria*. *Canadian J. Bot.* 72:182-188.

Schweitzer, H.J. and B. Polakowski. 1994. Past and current distribution of rare vascular plants in northern and western Poland. *Senckenbergiana Biol.* 73(1-2):189-214. [German]

Sekretareva, N.A. 1986. Floristic findings in the Penkignei Bay (Chukot Peninsula, Russian SFSR, USSR). *Botanicheskii Zhur.* (St. Petersburg) 71(5):677-683. [Russian]

Sharma, M.P. 1988. Additions to the pteridophytic flora of Chamoli district (India). *J. Econ. Taxon. Bot.* 12(1):230-232.

Smith, D.E. Chemical characters as a guide to the taxonomy of *Botrychium*. Ph.D. Thesis. Univ. Michigan, Ann Arbor.

Soh, W.Y., K.D. Kang and S.S. Hong. 1994. Variation of vascular tissue patterns in the roots of *Botrychium ternatum* (Thumb.). *Phytomorph.* 44(1-2):1-10.

Soh, W.Y. and Y.S. Kim. 1993. Ultrastructure of vascular meristems in the rhizome of *Botrychium ternatum*. *Korean J. Bot.* 36(4):357-362. [Korean]

Soltis, D.E. amd P.S. Soltis. 1986. Electrophoretic evidence for inbreeding in the fern *Botrychium virginianum* (Ophioglossaceae). *American J. Bot.* 73:588-592.

Soltis, P.S., D.E. Soltis and K.E. Holsinger. 1988. Estimates of intragametophytic selfing and interpopulational gene flow in homosporous ferns. *American J. Bot.* 75(11):1765-1770.

Stahl, P. 1987. Towards a new flora of the province of Halsingland, Sweden. *Svensk Botanisk Tidskrift* 81(1):7-16. [Swedish]

Stahl, P. 1990. *Botrychium virginianum*: A forest species preferring young succession stages. *Svensk Botanisk Tidskrift* 84(1):23-36. [Swedish]

Stevenson, D.W. 1976. Comparative morphology of the shoot apices and vascular systems of *Dennstaedtia cicutaria*, *Botrychium multifidum*, and *Lycopodium lucidulum*. Ph.D. Thesis. Univ. California, Davis.

Stevenson, D.W. 1980. Ontogeny of the vascular system of *Botrychium multifidum* (Ophioglossaceae) and its bearing on stelar theories. *Bot. J. Linnean Soc.* 80(1):41-52.

Stoll, R.J., Jr. M.W. McClain, C.M. Nixon and D.M. Worley. 1980. Foods of ruffed grouse (*Bonasa umbellus*) in Ohio, USA. *Ohio Fish Wildl. Rept.* 0(7):1-18.

Sun, B.Y., T.J. Kim, J.H. Park and K.S. Kim. 1994. Spore morphology of some ophioglossaceous species. *J. Plant Biol.* 37(1):43-51. [Korean]

Takahashi, A. and M. Kato. 1990. Anomalous secondary vascular tissue in *Helminthostachys zeylanica* (Ophioglossaceae). *Plant Systemat. & Evol.* 173(3-4):119-128.

Taylor, R.J. and C.E.S. Taylor. 1987. Additions to the vascular flora of Oklahoma (USA): IV. *Sida Contrib. Bot.* 12(1):233-237.

Tikhomirov, V.N. 1987. New data on the flora of Voronezh Oblast (Russian SFSR, USSR): 1. *Biologicheskie Nauki* (Moscow) 0(6):74-78. [Russian]

Vijayaraghavan, M.R. and N. Gautam. 1989. Sporogenesis in *Botrychium virginianum* (L.) Sw. *Proc. Indian Natl. Sci. Acad., Part B: Biol. Sci.* 55(4):271-276.

Wagner, F.S. 1993. Chromosomes of North American grapeferns and moonworts (Ophioglossaceae: *Botrychium*). *Contr. Univ. Michigan Herb.* 19:83-92.

Wagner, W.H., Jr. 1991. New examples of the moonwort hybrid *Botrychium matricariifolium-Botrychium simplex* (Ophioglossaceae). *Canadian Field-Nat.* 105(1):91-94.

Wagner, W.H., Jr. 1992. *Hiemobotrychium*, new section a new section of *Botrychium* subgenus *Sceptridium* from the southeastern United States. *Novon* 2(3):267-268.

Wagner, W.H., Jr. and F.S. Wagner. 1982. *Botrychium rugulosum* (Ophioglossaceae), a newly recognized species of evergreen grapefern in the Great Lakes area of North America. *Contr. Univ. Michigan Herb.* 15:315-324.

Wagner, W.H., Jr. and F.S. Wagner. 1983. Two moonworts of the Rocky Mountains: *Botrychium hesperium* and a new species formerly confused with it. *American Fern J.* 73:53-62.

Wagner, W.H., Jr. and F.S. Wagner. 1986. Three new species of moonworts (*Botrychium* subg. *Botrychium*) endemic in western North America. *American Fern J.* 76(2):33-47.

Wagner, W.H., Jr. and F.S. Wagner. 1990a. Moonworts (*Botrychium* subg, *Botrychium*) of the upper Great Lakes region, USA and Canada, with descriptions of two new species. *Contr. Univ. Michigan Herb.* 17:313-325.

Wagner, W.H., Jr. and F.S. Wagner. 1990b. Notes on the fan-leaflet group of moonworts in North America with descriptions of two new members. *American Fern J.* 80:73-81.

Wagner, W.H., Jr. and F.S. Wagner. 1993. Ophioglossaceae C. Agardh. Ader's Tongue Family. pp. 85-106 In *Flora of North America. Vol 2. Pteridophytes and Gymnosperms.* Oxford Univ. Press, New York.

Wagner, W.H., Jr and F.S. Wagner. 1994. Another widely disjunct, rare and local North American moonwort (Ophioglossaceae:*Botrychium* subg. *Botrychium*). *American Fern J.* 84(1):5-10.

Wagner, W.H., Jr., F.S. Wagner, C. Haufler and J.K. Emerson. 1984. A new nothospecies of moonwort (Ophioglossaceae, *Botrychium*). *Canadian J. Bot.* 62(4):629-634.

Walker, T.G. 1987. A population of *Botrychium lanuginosum* Wall. ex Hook. and Grev. from Papua New Guinea and its relevance to hybridization in pteridophytes with subterranean gametophytes. *Bot. Helvetica* 97(2):207-218.

Warmbrodt, R. and R.F. Evert. 1979. Comparative leaf structure of six species of eusporangiate and protoleptosporangiate ferns. *Bot. Gazette* 140(2):153-167.

Watano, Y. and N. Sahashi. 1992. Predominant inbreeding and its genetic consequences in a homosporous fern genus, *Sceptridium* (Ophioglossaceae). *System. Bot.* 17(3):486-502.

Watt, A.S. 1981. Further observations on the effects of excluding rabbits from Grassland A in East Anglia (England, UK) breckland: The pattern of change and factors affecting it (1936-1973). *J. Ecol.* 69(2):509-536.

Westman, G. 1996. A new locality for *Botrychium simplex* in Dalarna, Sweden. *Svensk Botanisk Tidskrift* 90(3):159-160. [Norwegian]

Whittier, D.P. 1978. Apospory in haploid leaves of *Botrychium dissectum*. *Phytomorph.* 28(2):215-219.

Whittier, D.P. 1981. Spore germination and young gametophyte development of *Botrychium* and *Ophioglossum* in axenic culture. *American Fern J.* 71:13-19

Whittier, D.P. 1983. Gametophytes of *Ophioglossum engelmannii*. *Canadian J. Bot.* 61: 2369-2373.

Whittier, D.P. 1984. The organic nutrition of *Botrychium* gametophytes. *American Fern J.* 74:77-86.

Whittier, D.P. and R.L. Peterson. 1984. Gametophytes of *Botrychium lunarioides* and their mucilage-coated rhizoids. *Canadian J. Bot.* 62(12):2854-2860.

Whittier, D.P. and R.D. Thomas. 1993. Gametophytes and young sporophytes of *Botrychium jenmanii* in axenic culture. *Intl. J. Plant Sci.* 154:68-74.

Wilson, M.L.B. 1975. Development of phloem in the stems of *Botrychium dissectum* variety *obliquum* (Muhl.) chute. and *B. oneidense* (Gilb.) House. Ph.D. Thesis. Univ. Illinois, Urbana-Champaign.

Woodhouse, R.M. and P.S. Nobel. 1982. Stipe anatomy, water potentials and xylem conductances in seven species of ferns (Filicopsida). *American J. Bot.* 69(1):135-140.

Young, K.R. and B. Leon. 1993. Observations on *Botrychium virginianum* (Ophioglossaceae), a fern uncommon in the eastern Andes of Peru. *American Fern J.* 83(3):93-96.

Zika, P.F and E.R. Alverson. 1996. Ferns new to the Wallowa Mountains, Oregon. *American Fern J.* 86(2):61-64.

Zou, X.M. and W.H. Wagner. 1988. A preliminary review of *Botrychium* in China. *American Fern J.* 78(4):122-135.